

Growing Red Raspberries in Ontario



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GROWING RED RASPBERRIES IN ONTARIO

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SECTION I

RED RASPBERRIES: PLANNING AND PLANTING

INTRODUCTION

The demand for red raspberries in Ontario is strong compared to the generally limited supply. In 1945, over 1300 ha of raspberries were grown across Ontario. This total dropped steadily to 230 ha in 1979 and has since doubled (Figure 1, Table 1). The major reasons for this decline were the limited availability of labour for harvest, continuous disease pressure (including viruses), weed pressure and high costs of production. Despite recent increases in total production, the supply continues to be limited. New cultivars, herbicides and recently introduced cultural practices have made raspberry production more profitable. However, too few pickers, high production costs and a highly perishable fruit continue to limit supply.

Table 1. Distribution of growers and area of raspberry plantings in Ontario according to the 1986 Census

Location	Number of Growers	Area (ha) in Raspberries
Southern Ontario	313	134
Western Ontario	230	161
Central Ontario	182	178
Eastern Ontario	122	131
Northern Ontario	44	18
Total	891	622

A high investment is needed to plant raspberries and the first returns are not realized until the third year. Long-term management of capital complemented with sound horticultural practices is required to maximize success. Aspects that the grower must consider include the market potential for raspberries in the local area, proper land preparation, planting procedures and proper care of established plantings. **This publication, in the first section, will present the major considerations needed to plan for and plant red raspberries. The second part outlines information for the care of established plantings.** For information on other brambles, see OMAF Factsheet *Growing Blackberries, Purple and Black Raspberries*, Agdex 234/20.

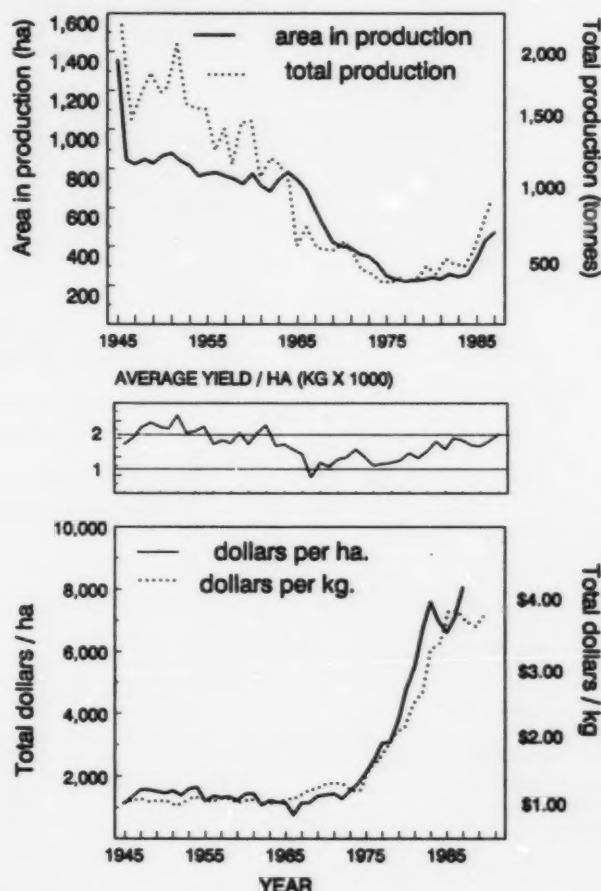


Figure 1. Production trends of raspberries in Ontario

Red raspberries are grown commercially in nearly all agricultural areas of Ontario. A good location is determined by the presence of a suitable soil and an available market. Raspberries are marketed through three channels: Pick-your-own operations, fresh market (retail or wholesale) and processing. Each market requires different production and business approaches. **Therefore, the grower must develop a good marketing and financial plan before planting.** For a successful pick-your-own (PYO) operation, the farm must be located near a large population center and not too near other raspberry producers. Too many growers in one area could saturate the market. To market fresh raspberries, a grower needs plenty of pickers, close proximity to markets and proper facilities to maintain berry quality. Processing raspberries requires a high capital investment and is marginally profitable unless it is carefully planned and a market is secured. Proper planning and a full commitment enhances success.

THE RASPBERRY PLANT

Raspberries are usually shallow rooted with three-quarters of the active roots in the upper 25 cm of soil and an additional one-fifth in the next 25 cm. The remaining roots can penetrate as deep as 1.75 m. The perennial roots remain viable for many years and give rise to shoots which live for 2 years. The shoots originate in the spring or fall as root suckers from buds on the roots or from basal buds on fruiting canes (stem suckers). Root suckers tend to be

thinner, shorter, more spiny and extend beyond their designated area. In the first year (Figure 2), the new cane grows vegetatively, then sets flower buds in the late summer, fall or early spring. In the second year, lateral branches, which later bear fruit, are formed on the overwintering cane. The most fruitful buds occur in the middle three-fifths of the cane. The fruiting cane dies after fruiting.

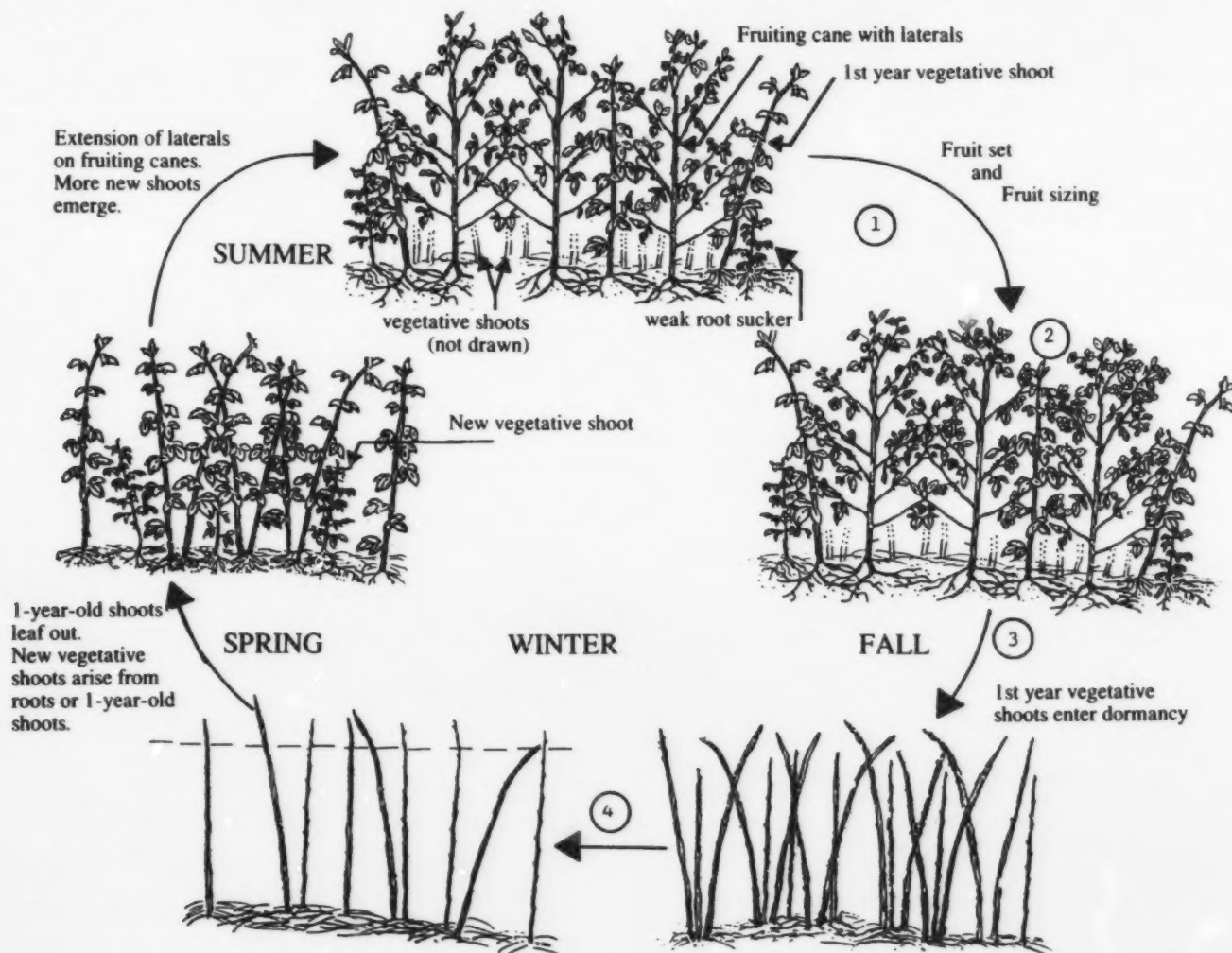


Figure 2. Generalized biennial life cycle of the mature raspberry plant. The main developmental stages are outlined in the figure. Circled numbers are management practices that must be carried out as outlined in Section II: (1) thin rows by removing root suckers that extend beyond the designated area; (2) harvest fruit; (3) prune out spent fruiting canes and weak or diseased vegetative canes; (4) thin vegetative canes to proper density and tip tops (dotted line).

Fall-bearing raspberries differ slightly in their growth habit. They will flower and produce fruit on the upper one-third of the canes in the first year of growth. Flowering starts when the vegetative cane develops a minimum (about 20) number of nodes. Therefore, flowering and cane height are affected by the summer temperatures. Early springs and warm summers promote early fruiting and limit cane

height, whereas cool summers delay the initiation of fruiting. Buds that do not fruit the first summer will do so the following summer (if the canes are allowed to overwinter). Occasionally, canes of summer-bearing cultivars such as "Comet" will fruit at the tips in the first year of growth, but this will not adversely affect yields the following summer.

SELECTING THE SITE

Site selection may be the most important consideration in the successful production of red raspberries. When selecting a site to plant raspberries the following factors should be considered (Figure 3):

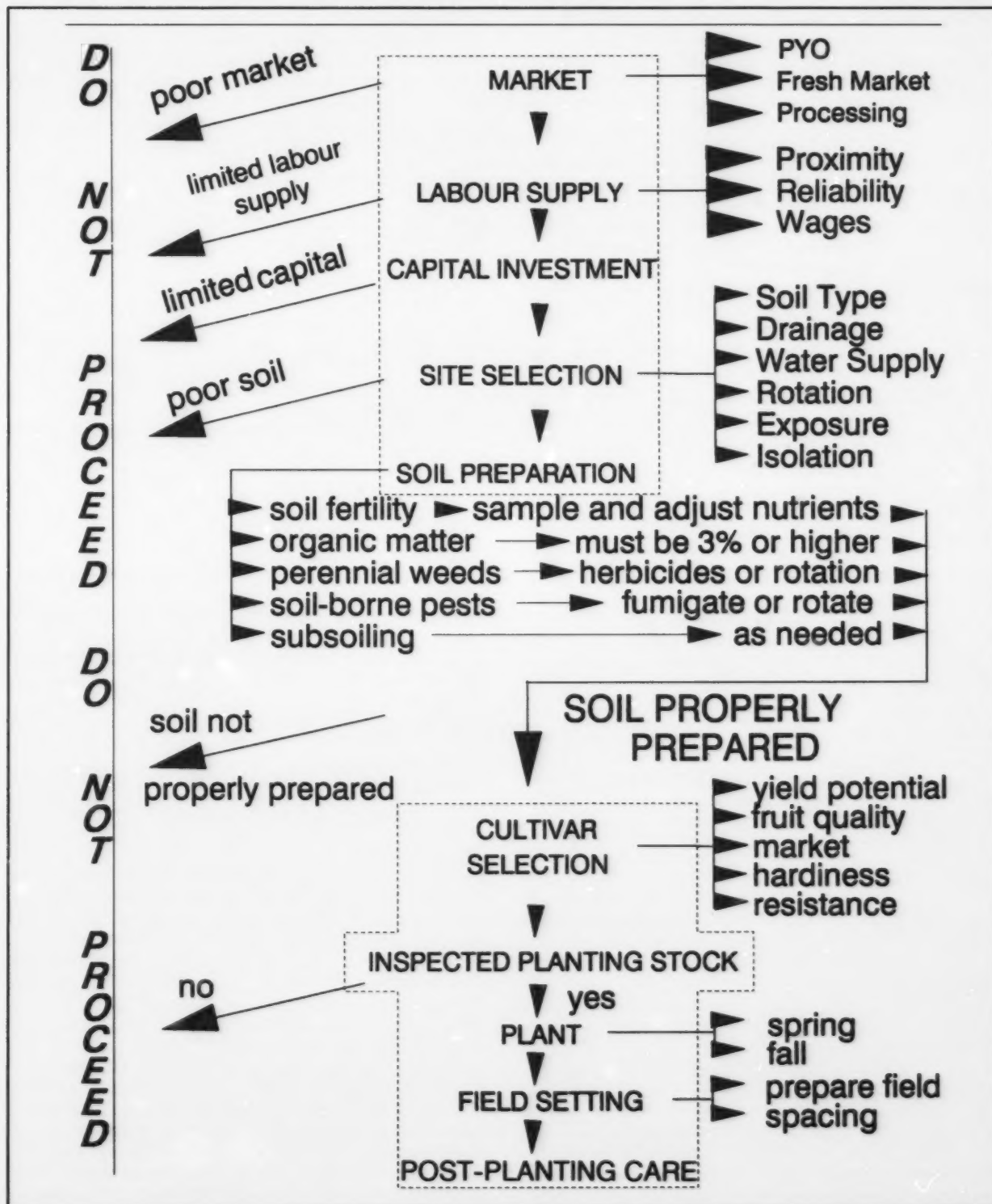


Figure 3. Flow chart of main factors to consider when planning and planting a new raspberry plantation.

SOIL Raspberries can be grown on a wide range of soils, but the ideal type is a deep loam or sandy loam soil with good water-holding capacity and drainage. Sandy or gravelly soils have poor fertility and dry out rapidly, requiring careful fertilizer and water management. Fine-textured soils with a high clay content are usually poorly drained and difficult to manage. Organic matter should be 3% or greater and can be improved before planting by using suitable rotation crops, manure, hay, straw or other soil amendments.

WATER DRAINAGE Actively growing raspberry roots will begin to suffocate and die if submerged in water for 24 hours or more. Poorly drained soils contribute to unproductive plants with poor vigour, problems with soil-borne diseases, and ultimately shorten the economic viability of the planting. Subsoils that are dense and compacted should be avoided, since the roots can extend to a depth of 1.75 m. (The water table should be below this level.) Planting in low-lying areas should be avoided.

Advice can be obtained from a reputable drainage contractor to determine the need for supplemental drainage such as tiling.

WATER SUPPLY Water for irrigation should be close to the planting site. Raspberries produce their fruit during the heat of the summer when rainfall can be limited. In most years, raspberry establishment, cane growth and fruit yields will benefit from irrigation. Trickle irrigation is the most suitable method of applying water to raspberries. Irrigation is discussed in greater detail in Section II: "Water Management".

In the absence of irrigation, a high organic matter content which improves the water-holding capacity of the soil or mulch can be used to retain soil moisture. Additional information on mulches is also outlined in Section II.

SOIL PREPARATION

Begin soil preparation at least one full year before planting to adjust soil fertility, improve the organic matter content and eliminate perennial weeds and soil-borne diseases and insects.

SOIL FERTILITY A soil test is the best means to determine the pH and nutrient levels in the soil. Soils should be sampled 15-30 cm deep from several sites to represent the field. Instructions for sampling and a list of recommended soil testing laboratories are available from OMAF county offices.

Raspberries grow best at a pH of 5.5 to 6.5. In Ontario, liming is recommended if the pH falls below 6.1 for coarse- and medium-textured soils and below 5.6 in fine-textured soils. Liming should precede planting by 6 to 12 months to allow the soil to adjust. The soil test will also reveal the necessary application rates for nutrients such as phosphorus, potash and magnesium. If high rates of potash are required, sulphate of potash or sulpomag should be used. Some root injury has been observed on sandy soil where muriate of potash (0-0-60) has been used at high rates. Likewise, excessive phosphorus levels can induce a deficiency of other essential nutrients. High levels of

PREVIOUS CROP Raspberries should not be planted after raspberries, strawberries, orchards, potatoes, tomatoes, eggplant or peppers. These crops harbour verticillium wilt, a root and crown disease. Similarly, nematode populations may be high in old raspberry, strawberry and orchard sites.

Fields where persistent herbicides have been used should be avoided or sampled to ensure that the residues will not damage the young raspberry plants. New raspberries should not be planted in a field where sod or forage legumes were grown the previous years because of potential problems with wireworms and white grubs.

EXPOSURE AND SLOPE Exposure and slope should be considered in site selection. Although steep slopes are prone to erosion and should be avoided, they can be managed by contour planting and growing sod between the rows.

Raspberries should be planted and managed to allow for maximum air drainage. This minimizes the incidence of low temperature winter injury, cane diseases and berry diseases, by decreasing humidity. Air movement is desirable, but high winds can be damaging. Exposed raspberry canes are susceptible to drying out during the winter and poor growth, cane whipping and breakage during the summer. Living windbreaks can offer protection on the leeward side for a distance of 8 to 12 times their height. The windbreak should be planted or managed to allow air drainage to minimize complications with cold injury and diseases. Detailed suggestions are outlined in OMAF Publication 527, *Windbreaks on the Farm*.

ISOLATION New raspberry sites are ideally planted away from old plantings or areas that harbour wild raspberries. Viruses are readily transferred by aphids, nematodes or pollen from infected plants to new plants. Isolation (150 to 300 m) will help to reduce the introduction of viruses.

nitrogen can lead to winter injury. Additional recommendations for fertilizer applications are outlined in OMAF Publication 360, *Fruit Production Recommendations*.

ORGANIC MATTER The organic matter (OM) level is important because of the various roles it plays in the soil. OM improves soil aeration, water-holding capacity, nutrient retention and soil tilth. The OM content can be improved with the use of manure, hay, straw or green manure crops.

There are several ways to improve the OM content of soils. The most traditional has been with the use of manure. However, for most raspberry growers manure is not readily available. Weed-free cattle or swine manure applied at 25 to 45 tonnes/ha is beneficial, especially if it contains bedding material. Manure that is decomposed can be applied in the spring, otherwise it should be applied during the previous fall and worked in. Poultry manure could be used, but it does not contribute as much to the soil OM. Where poultry manure is used only 9 to 11 tonnes/ha should be applied the fall before planting, since fresh poultry manure can burn the tender raspberry roots.

A good substitute for manure is hay or straw applied at 7 tonnes/ha. Unless the residue contains at least 1.5% nitrogen, the soil organisms will actually remove nitrogen (about 30 kg/ha) from the soil to break the residue down. Legume materials have enough nitrogen, but for non-legume material 4 kg N/tonne of hay or straw should be added at the time of application. As the residue breaks down most of the nitrogen will be slowly released and made available to the plants.

A third strategy, and often most practical approach to improve the OM, is to plant a green manure crop either in place of or in addition to the OM amendments described above.

Green manure crops are most beneficial where the soils are too light or too heavy and the OM is low, where no manure is available, and where a legume green manure crop can be used.

The appropriate green manure crop depends on the cropping system in place and current weed problems. If a grower is willing to forego a whole season, then a cereal crop underseeded with red clover in the early spring is an excellent choice for soil improvement. Red clover can be direct-seeded alone but companion cropping is recommended if straw or grain is required (for another use), if annual grass weeds are a problem, or if the site is prone to erosion. If direct-seeded, red clover could add as much as 140 kg of nitrogen/ha; with a companion planting, 90 kg/ha. Up to two-thirds of this nitrogen will be available to the next crop. The double-cut type of red clover is preferred to single-cut. Common seed is just as effective as pedigree seed for green manure purposes and costs much less. If red clover is planted for the first time in a field, the seeds should be treated with an appropriate *Rhizobium* culture to ensure the nitrogen contribution. The red clover should be cut or harvested by the end of July and then plowed down in the late fall. Root growth increases several fold in the fall of the seeding year, so plowing should be delayed as long as possible. On light soils where erosion is a concern, spring plowing is an option but this may delay opportunities for timely planting of the raspberries.

Other useful green manure crops are annual and perennial rye grasses. An annual rye grass of the Westerwold type could be planted in early April to late May or early August to early September. The heavy root and rapid seedling development make annual rye grass useful for improving soil structure, especially in the top 10 to 20 cm. Similar to red clover, most root growth occurs in the fall. Italian rye grass (perennial type) could be planted at the same timings at 22 kg/ha. Italian rye grass has an extensive fibrous root system and vigorous top growth which provides substantial material for incorporating into the soil in the early spring. Although it is not considered winter hardy in Ontario, it often survives the winter. Adequate tillage or an appropriate herbicide may be necessary to kill it off in the spring.

Grain crops such as rye, oats or barley are also used commonly as green manure crops. Again, there are several approaches that can be taken. Some growers plant their rye in the fall, allow it to go to seed the following season, disk it under late July or early August and then allow volunteer rye to grow as a fall cover crop. Alternatively, if the land will be used for the early season, then a cereal crop can be seeded from mid-August to mid-September

to provide enough growth for green manure before the winter. Rye is the most common crop seeded this way. Oats is also used and sometimes favoured because it will winterkill. Barley also normally winterkills. In all cases the recommended seeding rate is 7.5 bushels per hectare (3 bushels per acre which is equal to 170 lbs, 110 lbs, and 144 lbs per acre for rye, oats and barley respectively). A cereal could be planted almost any time of the year and the timing depends on moisture conditions and the grower's management strategy. Perhaps, if the field is going to be fumigated, the cereal should be planted and worked under early in the season to allow adequate decomposition before fumigating. Also, cereal green manure plantings may require an appropriate herbicide application (depending on the weed problems) to control weeds as outlined in OMAF Publication 75, *Guide to Weed Control*. Finally, when plowing down a non-legume green manure crop about 30 kg/ha of nitrogen should be added to aid decomposition.

Other green manure crops occasionally used include buckwheat (do not allow to go to seed), sudan grass (provides abundant green manure and appears to be a poor host for nematodes), sorghum, oil seed radish, sweet clover and hairy vetch.

Where potential problems with nematodes exist the green manure crop must be carefully chosen. For example, of all the cereal crops, wheat seems to encourage nematode populations the least. Dagger nematodes may be numerous in established legume crops. Additional information can be obtained from an OMAF Horticultural Crop Advisor.

Additional information on the use of organic amendments is outlined in OMAF Publication 360, *Fruit Production Recommendations*.

PERENNIAL WEEDS Perennial weeds, such as quackgrass, Canada thistle, bindweed, vetch, horsetail and others should be eliminated before raspberries are planted (Figure 4). Summer fallowing with frequent cultivation can reduce perennial weed problems, but is expensive and decreases the organic matter content of the soil. Therefore, a suitable herbicide applied at the proper time before planting is a preferred option. Directions for weed control are given in OMAF Publication 75, *Guide to Weed Control*.



Figure 4. Newly-planted field of raspberries showing initial spacing and new growth of vegetative canes. All perennial weeds were removed prior to planting.

INSECTS AND DISEASES Where wireworms or white grubs are a problem, an annual row crop such as corn or pumpkins could be planted to reduce the insect populations.

The soil should be tested for nematodes where a problem is suspected. Nematodes build up in sandy to sandy loam soils and can be controlled through fumigation. Ideally, fumigation is done in the fall prior to planting while soil temperatures are at least 4° C at the 15 cm depth. Fumigation may be justified for the control of certain soil-borne diseases and weeds in addition to nematodes. This approach is expensive, but may be justified where normal practices of crop rotation and land preparation cannot be followed.

Also, raspberries should not be planted immediately after a previous crop of raspberries without fumigation due to problems known as "replant disorders". Field observations have shown that factors causing replant disorders can persist for 5 to 6 years. High rates of recommended fumigants help to overcome the disorder. Replant disorders appear as stunted and non-vigorous plants.

PLANTING

SELECTION OF PLANTS Raspberry cultivars should be selected for their potential market (PYO, processing, or retail), winter hardiness, relative disease resistance and fruit quality. With carefully chosen cultivars, raspberry production is feasible in most agricultural areas of Ontario. Cultivars can also be selected according to the time of ripening to spread out or concentrate the season. Descriptions of cultivars recommended in Ontario are outlined in OMAF Publication 430, *Fruit Cultivars*.

USE INSPECTED PLANTING STOCK The productivity of the planting is often directly related to the quality of the original plants. Non-certified or uninspected plants may be infested with viruses, nematodes, crown gall, root diseases or other problems. The Ontario Fruit and Vegetable Grower's Association in cooperation with Agriculture Canada and the Ontario Ministry of Agriculture and Food operate a quality plant program. Each year, a list of recommended Ontario propagators participating in the program is available from OMAF offices. Plants are derived from virus-tested stock, grown in fumigated soil and inspected by OMAF inspectors before being approved for selling.

TIME OF PLANTING One-year-old dormant plants are the best and most common source of transplants. The plants are dug up by the propagators in the late fall or early spring when they are fully dormant. They should be planted as soon as possible after arriving on the farm or held in cold storage (-1 to 0° C) until planting time.

The ideal planting time is early spring as soon as the soil can be prepared. It is better to delay planting than to work soils when they are wet. Plants should be ordered in the fall or early winter for delivery in the spring. Some raspberries are successfully planted in late October or early November before the soil freezes. At this time there are fewer demands on labor and plants set in the fall are ready to grow in the spring when conditions become favourable. A light mulch application is recommended to minimize frost heaving or winter injury to the plants.

Information on the need for nematode sampling and the need for fumigation can be obtained from an OMAF Horticultural Crop Advisor or Pest Management Advisor. Additional information on soil sampling, soil preparation, timing and fumigation rates are outlined in OMAF Publication 360, *Fruit Production Recommendations* and the OMAF Factsheets, *Nematode Control Guidelines for Application of Soil Fumigants*, Agdex 628, and *Soil and Root Sampling for Nematode Analysis*, Agdex 628.

SUBSOILING An impervious subsoil layer or hardpan due to compaction can be broken up by subsoiling. Subsoiling should be done twice at right angles when the soil is dry, as commonly occurs in late summer, to encourage the shattering of the hardpan. Subsoiling when soils are wet will increase rather than decrease compaction problems.

Note: Mulch application usually leads to volunteer grain problems from the straw.

SPACING Red raspberries are most commonly trained in a hedgerow system. The plants are spaced 60 cm apart in rows 210 to 300 cm apart (Figure 4). They will form a continuous row within 2 years. The distance between the rows is determined by the type of equipment that will be used but should be as narrow as practical (i.e. if the rows are too close, less than 210 cm, then it becomes difficult to walk between the rows during the fruiting season).

Plant fall-fruited cultivars 60 cm apart within the row and keep the distance between the rows as narrow as practical for maximum yields per hectare.

The number of plants needed per hectare can be calculated by dividing 10,000 m²/ha by the number of square metres needed per plant. For example, to determine the number of plants/ha for plants spaced 60 cm in rows 240 cm apart the calculation would be:

$$\begin{aligned} 0.6 \text{ m} \times 2.4 \text{ m} &= 1.44 \text{ m}^2 \text{ per plant} \\ 10,000 \text{ m}^2 \text{ per ha} / 1.44 \text{ m}^2 &= 6,944 \text{ plants per ha} \end{aligned}$$

FIELD SETTING The soil should be worked to prepare a reasonably loose and deep "planting bed". Straight rows can be marked out using a tractor drawn marker or by stretching a string over the rows. The plants may be set:

1. with a mechanical planter modified for raspberry plants (e.g., an old transplanter that simply opens up the furrow and repacks the soil around the plants works well. In this way water and starter fertilizers can be added easily at the time of planting)
2. in a ploughed furrow
3. in holes dug with a shovel

The roots should be planted in the furrow or hole with the roots spread out as much as possible. Soil should be placed over the roots, firmed in and levelled so that the plants are slightly deeper than they were in the nursery (there will be a soil line on the plant). Prune the dormant cane to 15 cm above the ground. When the first new

vegetative canes appear above ground, the fruiting cane (handle) can be removed completely. If the original cane is allowed to grow, it will do so in competition with the new canes by producing fruit. All the plants' energies should be directed into producing vigorous vegetative shoots.

Do not let the roots dry out during planting. Wrap the

roots in moist burlap or carry them in water (for short periods of time). If planting is delayed, hold them in cold storage or vertically heel plants into moist soil with the roots spread out. Do not store plants with apples or other ethylene-producing produce.

CARE AFTER PLANTING

WATERING After planting, the raspberries should be watered and a regular irrigation schedule maintained if sufficient moisture is not present. Additional information on determining the need for irrigation is outlined in Section II: "Water Management".

WEED MANAGEMENT Weeds can be controlled by hand, mechanically or with chemicals as outlined in OMAF Publication 75, *Guide to Weed Control*.

If cultivation is used between the rows, work the soils to a shallow depth — just enough to remove weeds and undesirable suckers. Cultivation should stop in July and a cover crop can be seeded between the rows in early August (the cover crop will reduce yields if planted too early). The cover crop competes for moisture and nutrients and will encourage raspberry plants to harden off to withstand winter conditions. This is especially important with soils that have a naturally high fertility level. The cover crop also reduces soil erosion. If not winterkilled, the cover crop is worked into the soil in early spring.

PERMANENT SOD COVER Once the planting is established, a permanent sod cover can be grown between the rows. A sod cover permits easy access for pickers and machinery. The sod can be fall or spring seeded at 20

to 22 kg/ha using creeping red fescue. The grass used should not compete with the raspberries. Creeping red fescue has moderate vigour, is relatively resistant to traffic and goes dormant during the hot summer, minimizing moisture loss. The sod must be maintained with occasional fertilization and possibly irrigation to compete against perennial weeds. Raspberries may need additional nutrients and water to compensate for the effect of the sod. Additional information on sod establishment and maintenance is described in OMAF Publication 360, *Fruit Production Recommendations*.

FERTILIZATION No fertilizer is needed after planting during the first season if nutrients were properly incorporated beforehand as recommended by the soil test. Occasionally, on light soils or in wet springs, broadcasting a light application of nitrogen over the rows 2 to 3 weeks after planting may prove beneficial. Avoid excessive N application too close to the roots or they may be damaged.

PEST AND DISEASE MANAGEMENT Information on insect pests and diseases are outlined in OMAF Factsheet, *Insect and Diseases of Cane Fruits*, Agdex 230/605. Control recommendations are listed in OMAF Publication 360, *Fruit Production Recommendations*.

SECTION II

CARE OF ESTABLISHED PLANTINGS

INTRODUCTION

This second section discusses pruning, trellising, general care and harvesting of established raspberry plantings. Pruning and trellising have a major affect on the long-term productivity of raspberry plantings. These practices can be

very expensive in terms of labour and materials, so care must be taken when using certain pruning and trellising techniques.

PRUNING

Raspberries produce new shoots each year. Shoots are biennial. They grow to their full height the first year, fruit the following year and then die (Figure 2). The purpose of pruning is to remove the spent fruiting canes, limit cane density to optimize yield and quality, minimize disease problems, control suckers to maintain a certain row width and to clip the tops.

There are several types of pruning systems. The economics of each system have not been systematically compared and one system may perform better than another under different conditions. Therefore, a single training program is not presented but the options are outlined on the following pages.

ANNUAL SYSTEM This is the most common pruning system in Ontario (Figure 2). The first year canes (vegetative canes) and the fruiting canes grow together so that the plantation yields fruit every year. After harvest, the canes that just finished fruiting are pruned out as soon as possible (or as labour permits). The canes are cut at ground level with hand or air-assisted pruners, removed from the field and destroyed. The fruited canes often have cane disease problems and in certain years act as a source of inoculum for diseases that can spread to the new vegetative canes. Poor air circulation, caused by overcrowding of canes, also leads to the build-up of cane diseases on the new canes, limiting the crop potential for the following year.

In the late fall or early spring remove weak, diseased and broken canes (Figures 5a-5c). Short suckers within the row should also be removed, since they will bear little fruit, but significantly reduce air circulation in the lower canopy. Pruning vegetative shoots in late summer should be avoided for three reasons: (1) winter injury to a thin stand of canes can result in an inefficient cane density the following spring; (2) heavy pruning of vegetative canes removes food reserves for the crown, so it becomes weaker; and (3) thinning in late summer encourages the remaining canes to grow late into the season potentially causing winter dieback. Thinning of vegetative canes should be left until the early spring after severe cold temperatures have passed.

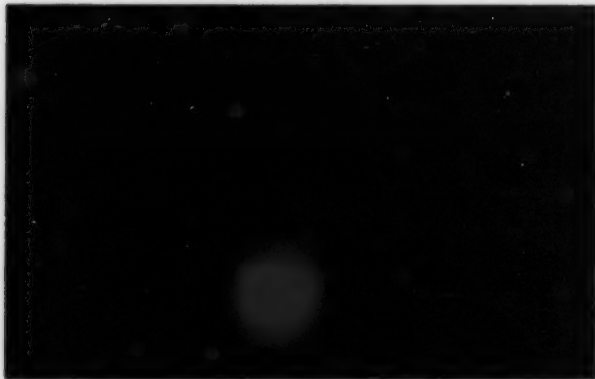


Figure 5a. Red raspberry canes in the fall before any pruning. The old fruiting canes are still present.



Figure 5b. The same canes after the old fruiting canes were removed in the fall.

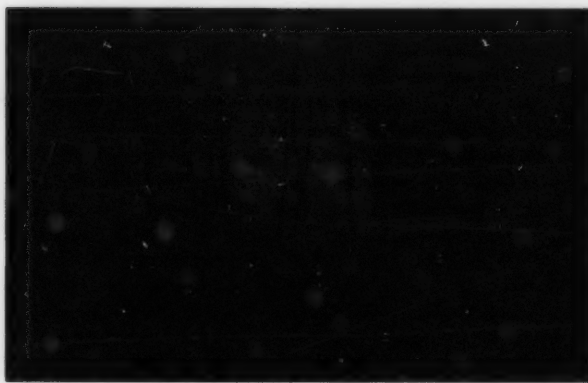


Figure 5c. Canes after pruning in the early spring. Weak canes were removed, the row was thinned to confine row width and the canes were shortened slightly.

The best yields, without compromising fruit size and quality, occur at a cane density of 10-15 canes per linear metre of row depending on the cultivar, soil fertility and moisture levels (Figure 6). Rows are narrowed to 30 cm wide. The most healthy, vigorous canes with good height and diameter should remain after pruning. When there are too many canes, lower laterals do not develop and often die out in the shade, lowering yields. A thick stand of canes also reduces fruit size dramatically and increases problems with mites and cane diseases.

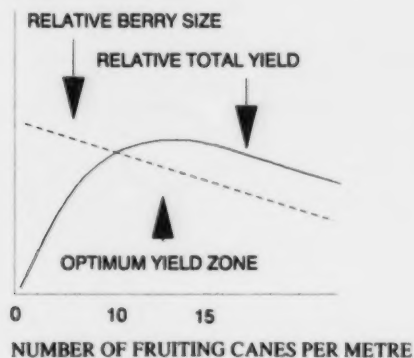


Figure 6. Berry size and total yield as influenced by cane density after pruning in the spring. Optimum yields occur with a cane density of 10 to 15 canes per metre (data from Dr. A. Dale, HRIO, Simcoe).

To minimize pruning, keep the rows narrowed to 30 cm continually throughout the growing season. This should start when the young canes are 10 cm high and should be repeated at regular intervals. This reduces the competition of canes, which would otherwise be pruned out in the winter, and enhances yield.

The ideal approach (going through the patch twice) may not always be the most economical approach. Some producers with vigorous plantings do all their pruning in August to September without sustaining an excessive amount of winter injury. Others, who have low disease pressure, save all their pruning till spring. The advantages and disadvantages must be weighed carefully when deciding on which approach to use.

CANE VIGOUR CONTROL Cane vigour control is not recommended in areas where plants are under any form of stress (e.g., drought or nutritional stress), and should only be tried in vigorous plantings where the season is long enough to allow for sufficient regrowth. The effect of cane vigour control varies according to the management practices and cultivar planted. Research at the University of Guelph suggests that cane vigour control is not successful in Ontario due to the low vigour of plantings compared to those in British Columbia. Removing the first flush also removes the best canes with the most yield potential. Therefore, the techniques for this training system are presented to familiarize Ontario producers with cane vigour control as reported in other raspberry-producing areas in North America. However, this approach for training raspberries is not generally recommended in Ontario, except on an experimental basis.

In locations where cane vigour control is successful, higher yields and berry quality occur when canes are selectively thinned in the early spring and the first flush of new growth is removed in late spring. In general, the more the new vegetative growth is reduced, the greater the fruiting cane yields will be that year. The yield in the following year depends on the number of vegetative canes that are allowed to grow and overwinter into the next year and can easily be reduced to nothing with improper treatment. Therefore, yields must be considered over a 2-year period to balance the competition between the fruiting canes and vegetative canes. Where cane vigour control is used, the canes must be removed when the first flush has grown 10 to 20 cm. A cane vigour control program should not be initiated until the planting is at least 3 years old. Yearly removal of the first flush results in a progressive decline of vigour. The greater the height at which the first flush is removed, the sooner the vigour declines. Every third or fourth year the first flush should not be removed to allow vigour to be regained.

No chemicals are available for cane vigour control suppression, resulting in expensive hand labour requirements. Alternatively, the whole first flush does not need to be removed. New shoots can be removed in late spring, leaving 10 to 15 shoots/m when the shoots are about 20 cm high. The next flush of new shoots are allowed to grow, but are pruned out early in the following spring. This approach improves the current season's yield (compared to complete primocane suppression of the first flush) and thinning is done with young succulent canes rather than large thorny canes. However, in late spring all the leaf growth is a hinderance to selective pruning.

BIENNIAL CROPPING One approach to eliminate detailed pruning and reduce spraying cost is to alternately mow half of the planting each year (Figure 7). In this system, all the canes are mowed off every other year after the crop has been harvested. Where this system is used, every other row can be mowed or half the field can be mowed, which ever is most practical for managing the plantation and harvest labour. The half that was not mowed will bear the crop.

Mowing should only be done after the canes have become fully dormant and before dormancy starts to break (i.e. between late November and early March). In the spring and through the summer, the vegetative canes are able to grow without competition from fruiting canes. The following year, the overwintering canes (now called fruiting canes in



Figure 7. The row in the center was mowed in the fall. New vegetative canes are emerging in the spring and will bear fruit the next season. The outer two rows will be harvested this season and then mowed off in the fall after entering dormancy.

the second year of their growth) will fruit but fruiting will occur in competition with the new first year canes. The fruited rows are mowed again in the dormant season. This system reduces labour costs, but fruit size and quality are also reduced. Total yields over a 2 year period are considerably lower than a well-managed annual system. One of the reasons for the yield reduction is that there are too many canes produced in this system during the cropping year. Pruning to 10-15 canes per metre will improve yields. Yields and fruit quality can be increased if the vegetative canes are suppressed during the fruiting year (i.e. a truly biennial system where fruiting and first year cane growth occur in alternate years), but the lack of suitable chemicals makes this approach impractical.

SUCKER CONTROL Suckers arise from the extended roots of raspberry plants and must be removed to keep the row narrow and optimize yield. Techniques of removing these suckers include periodic mowing where a permanent sod exists or shallow cultivation. Refer to comments in section I: "Care After Planting: Weed Management" or to "Weed Management" later in this section for additional information on cultivation.

TIPPING In most conventional production systems raspberry canes are tipped in early spring to remove tips with winter injury or to keep the canes to a convenient harvesting height. This is done manually or mechanically (e.g., adapted hydraulic sickle mower mounted on a front end loader). Tipping should be done conservatively since yields will be reduced. A typical cane produces 15%, 40%, 30% and 15% of its fruit from the top to lower quarter respectively (Figure 8). Tip only if required and tip only as much as necessary. Some producers tip plants to ease harvesting procedures. A convenient height is 1.5 m.

Unlike purple or black raspberries and blackberries, there are no benefits to pinching red raspberry vegetative cane tips during the growing season.

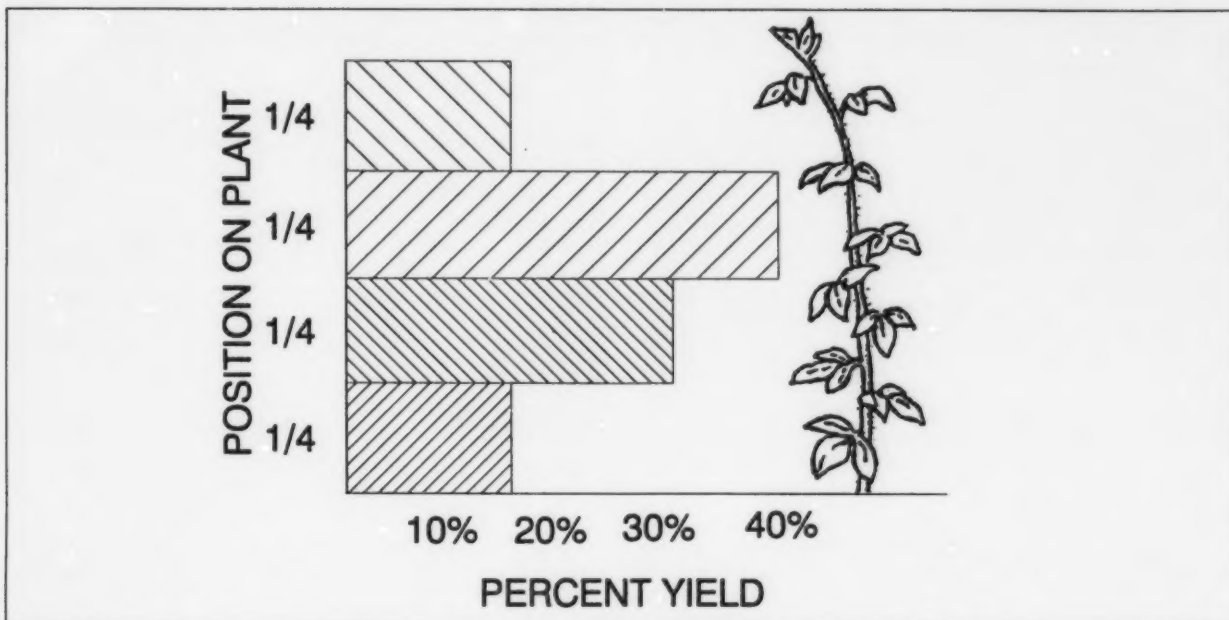


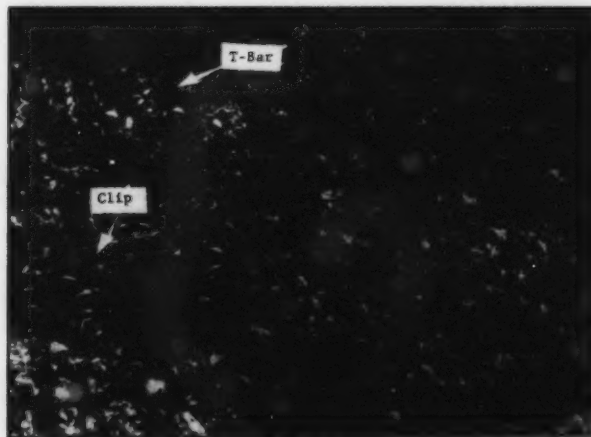
Figure 8. Distribution of yield on a typical raspberry fruiting cane. Excessive shortening of the canes will result in reduced yields.

TRELLISING

In general, trellising raspberries increases yields over free-standing canes primarily by improving light penetration into the canopy. Most red raspberry cultivars need support, as the fruiting canes fall over from the weight of the fruit and hamper spraying and harvesting procedures. The common trellising systems include the vertical or "I" trellis, "V" trellis and "T" trellis. The "V" and "T" trellises require more initial capital costs, but do have some management advantages and usually provide higher yields. Trellis-

ing is not always needed during the first harvesting year (except for very vigorous cultivars), and can be built in the fall or early spring after the first harvest when there has been some cash flow.

The vertical trellis is simple in design (Figure 9). Posts are driven in the soil every 7.5 to 9 m. The posts should be long enough to be well anchored in the soil (at least 60 cm) and high enough (e.g., 1.5 m) to support the canes.



Figures 9a and 9b. An aesthetically pleasing PYO raspberry planting employing the "I" trellis design for cane support. Twine is stretched from wooden end posts (9a) that provide the main support. Every 7.5 to 9 m metal T-bars (9b) provide additional support for the trellis. Every 3 m (or as needed) twine or wire clips are used to hold the 2 strands of twine together (9b). For tall raspberry canes, 2 levels of twine are stretched from end to end. This

raspberry planting is well suited to the PYO business. Rows are clearly labelled (27 N 28) and run north or south from a central path that extends across the planting. Sod is well maintained between the rows for easy foot traffic and weeds are managed within the rows using band herbicide applications, spot treatments and hand work. The small stake (9a) is red and used to mark the length of the row that has been picked.

Polytwine or nylon bale twine is stretched along each side of the posts at a height of 1 to 1.5 m according to the height of the fruiting canes. This double-line system holds the fruiting canes in a narrow row. As the fruit develops, the twine will tend to separate, but the two lines can be held together using wire clips or tied twine. The trellis lines are rolled up to end posts after harvest to allow for easy pruning. This training system is simple, but forms a tight canopy structure that limits light penetration in the lower canopy and forces the new vegetative canes to grow toward the outside. These vegetative canes surround the fruiting canes and interfere with harvesting.

The "V" or "T" trellis systems separate the fruiting canes from the vegetative canes. In principle, the fruiting canes are spread out to one or both sides and the vegetative canes are allowed to grow freely into the middle. Supporting posts can be placed every 7.5 to 9 m apart. End posts are anchored at a 30 degree angle away from the row to anchor the wires for extra support. The "V" style is engineered by using 2 steel posts angled outwards from the vertical on each side (Figure 10). For the "T" style (Figures 11 and 12), single posts are used with crossarms 70-140 cm across. Support lines are then stretched from post to post or crossarm to crossarm. The "T" trellis is less flexible since it is difficult to adjust the height of the wires according to the height of the canes.

There are many modifications to the "V" and "T" trellis systems. Success of the modifications depend on the vigour of the variety, desired effect and economic feasibility. There are "one-sided" and "two-sided" modifications.

With the one-sided system, the canes that will fruit are tied to one side of the trellis in early spring. The new

canes grow along the side of the row away from the fruiting canes in the direction of maximum sunlight. In the "T" system, rather than tying the canes, one approach is to have a third wire on a swinging arm fixed to each post to hold the canes against the side wires. The wires are clipped together every 3 m or so. The following spring, the third wire is swung to the other side to hold the new fruiting canes against the wire on that side. To eliminate detailed pruning, all the canes can be mowed off on the fruiting side after harvest and canes on the opposite side are allowed to fruit the following summer (i.e. alternately mowing half the row).

With the two-sided system, the fruiting canes are tied to both sides of the "V" or, in the "T" system, they can be held in place by using 2 extra wires.

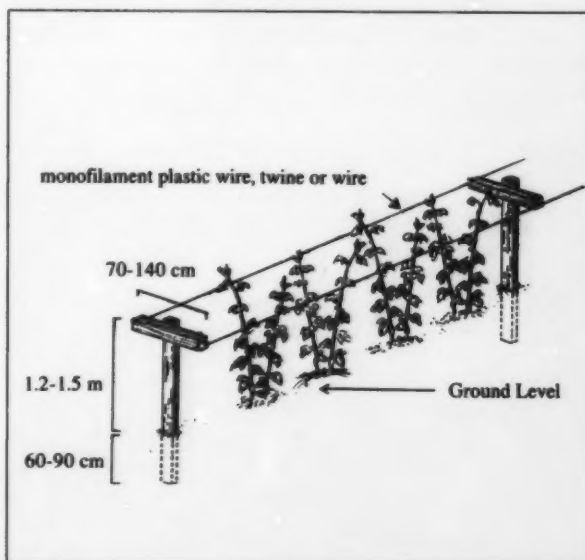


Figure 11. "T" trellis design. Height of the trellis and width of the cross-arms are dependant upon the cultivar's growth habit.



Figure 12. "T" trellis design with the fruiting canes trained to the outside wires that allows new shoots to grow freely in the center. Fruiting canes can be tied to the outside or held in place with a second set of wires or twine.

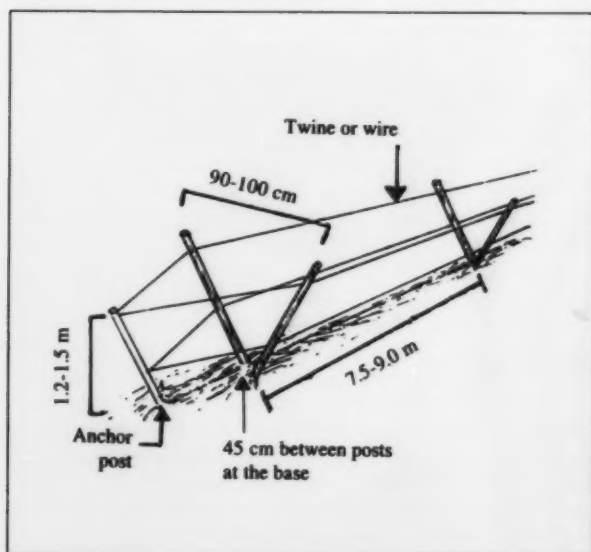


Figure 10. Typical "V" trellis design with steel posts angled outwards from the center. The distance between the posts at the base is 45 cm and 90 to 100 cm at the top. Twine is fed through eyes or loops in the bars, stretched from post to post and anchored at the ends by another post angled away from the row. Fruiting canes are trained to the outside, allowing new shoots to grow in the center.

If the fruiting canes are spread out in the early spring, the laterals tend to grow back into the center complicating harvesting. To avoid this problem, spread the canes out after flowering is initiated. This can be done by having 2 wires stretched down the centers of each row. At bloom, the wires are moved toward the outside set of wires taking half the fruiting canes to each side. The wires are clipped together every 3 m or so. The advantage of this system is that fruiting laterals are forced towards the outside, making harvest

easier; however, fruiting laterals can be extensively damaged during the spreading process.

When using wires, 10 gauge galvanized wire is preferred for the main supports and 14 gauge wire can be used for spreading. Monofilament plastic wire has also been used successfully since it is strong and is easier to handle. Posts that are selected should have a life expectancy of 10 or more years.

PRUNING AND TRELLISING FALL-BEARING RASPBERRIES

Canes of fall-bearing raspberries will fruit during the first year in late summer or early fall (Figure 13). This is referred to as first-year bearing or primocane fruiting. If the canes are allowed to overwinter, fruiting will occur in the late summer on the laterals that did not bear fruit the previous fall. However, it is most common to only harvest the fall crop.



Figure 13. Fruit load of the fall-bearing raspberry "Redwing" in the middle of August under evaluation by Dr. A. Sullivan, University of Guelph.

After the late-season harvest and once the canes become fully dormant, the fruited canes are simply mowed off and the following year new canes will emerge to bear fruit the next fall. The canes should be mowed as close to the ground as possible so the buds break from below the soil surface. Buds from above the surface will fruit in the summer which is not desirable. Leaving the canes for a second year does not make use of the advantage of fall bearers (i.e. their ease of pruning by mowing). However, some experience in the Leamington area has shown that the summer crop (August) of the cultivar "Heritage" is acceptable in addition to the fall crop.

A brief note on fall-bearing raspberries should be interjected here. Watering is important for the production of large fall berries, extra nitrogen is needed in July - August and fall-bearing raspberries don't like extreme heat. Fall raspberries also tend to have more problems with fruit rot because of wet conditions that can prevail in the fall.

If the canes grow high and bend over with the fruit load, harvesting will be difficult. A simple "T" trellis works well for cane support. If this trellis is permanent, the posts will interfere with mowing. One approach is to prepare holes 60 to 80 cm deep and lined with PCV piping. Trellis poles with crossarms (90 cm wide) are simply dropped in the PCV-lined holes when support is needed but taken out for mowing. Twine can be tied to the crossarms for cane support.

NUTRITION MANAGEMENT

The objectives of a soil fertility program are to:

1. maintain an adequate organic matter content in the soil;
2. promote rapid growth in spring and early summer;
3. slow growth in late summer and fall so canes will mature and harden off properly before the winter.

A permanent sod maintains the organic matter. Where aisles are cultivated a cover crop seeded down in late August will contribute organic matter and encourage the canes to harden off as outlined in Section I: "Care After Planting."

Recommended fertilizers should be applied in the early spring when growth begins. Late fertilizer application encourages late growth and should be avoided. The fertilizers are commonly applied in the row using a 3-point hitch fertilizer spreader fitted with a banding applicator.

Raspberries require 16 different types of nutrients in appropriate and balanced amounts. Fertilizing needs are determined primarily through soil test analysis, but a leaf analysis is also useful. Information on sampling procedure and interpretation of results is available from a local OMAF Horticultural Crop Advisor.

Poor growth does not necessarily indicate a lack of nitrogen (N), since poor drainage, lack of moisture or disease can be responsible for this symptom. Excessive N induces too much growth, which reduces the number of berries per cane the following year and increases the potential for winter injury. For this reason, manure should be used with caution, since high levels of N could be released late in the season.

The amount of N needed depends on the soil type, cultivar, soil moisture level, plant age and cultural practices. Higher levels of N are needed for lighter soils, fall-bearing cultivars (as described earlier), older plantings and mulched plantings.

A good soil fertility program usually supplies all the nutrients needed for maximum production. However, foliar-applied fertilizers are effective in correcting a known deficiency problem, especially if it is boron, manganese, iron or zinc that must be applied. Additional information on fertilization is outlined in OMAF Publication 360, *Fruit Production Recommendations*.

WEED MANAGEMENT

Most raspberry plantings, especially Pick-Your-Own (PYO) operations, have permanent sod between the rows for ease of harvest and weed management (Figure 9). The sod should be maintained to prevent weeds from becoming established. Information on establishing a permanent sod has been described in Section I: "Care After Planting: Permanent Sod Cover".

Alternatively, cultivation between the rows will limit weed growth and remove raspberry root suckers. Since raspberries are shallow-rooted, do not cultivate deeper (e.g., with a rotary-type cultivator) than 10 cm in the center of the aisles and 5 cm near the rows: just deep enough to remove weeds and undesirable root suckers. Cultivation is stopped at harvest so the plants will harden off sufficiently.

In the rows, herbicides are the most common means of controlling weeds. A swivel nozzle with two nozzles extending from the spray tank works successfully for applying water-carried herbicides. The spray tank is mounted on the 3-point hitch or trailer drawn at the rear of the tractor. Nozzles are positioned on the tank so the spray penetrates into the raspberry row along the base of the

canes. With swivel nozzles, one nozzle can be set to penetrate into the center of the row and the other nozzle set to spray the outside of the row. A handgun directly off the tank could also be used.

A hand-held or tractor-mounted air-assisted granular applicator works well for granular herbicides. These may be rented or bought from your dealer/distributor. One novel approach is to use a litre jug with the bottom removed and a hole drilled in the cap. The jug is filled with the granular herbicide and the applicator walks along the row allowing the granules to leak out of the jug, hit the canes and be dispersed. Calibration and broadcast pattern are more difficult to keep consistent, but the approach is useful for small plantations. One person can do a hectare in 75 to 100 minutes.

Successful weed control improves yields, reduces problems with rodents, allows for good air circulation and improves the aesthetics of the planting.

Specific weed control recommendations are outlined in OMAF Publication 75, *Guide to Weed Control*.

MULCHES

Mulches such as straw, old hay, sawdust or planer shavings have been used successfully, but good soil management, herbicides and irrigation provide the benefits attributed to mulching without the problems.

A mulch 10 to 15 cm thick will help to preserve soil moisture, reduce soil temperatures and daily temperature fluctuations, provide some weed control and limit erosion and frost heaving (Figure 14). Mulches encourage raspberry roots to develop near the soil surface, making them more drought susceptible in the absence of irrigation. Mulches also tend to delay the hardening-off process resulting in more winter dieback; they also decrease the available nitrogen, inactivate a portion of applied preemergent herbicides and are relatively expensive to apply.

Therefore, mulches are not generally recommended, but may play a role where erosion or frost heaving is a problem.



Figure 14. Raspberry planting showing the use of mulch for additional winter protection of the crowns and roots.

WATER MANAGEMENT

Irrigation is essential for optimum raspberry production in most years. Irrigation ensures early summer growth and sizing of the fruit during harvest. Adequate water is

also required in the fall to ensure proper cane hardening and flower initiation. Two types of irrigation systems are used: trickle and overhead.

TRICKLE IRRIGATION With trickle irrigation, water is slowly applied directly into the rooting zone using low pressures and flow rates. Water is applied daily during

peak water use. A basic system consists of a pump, filters, flow meter, main line, pressure reducing valves, lateral lines and emitters (Figure 15).

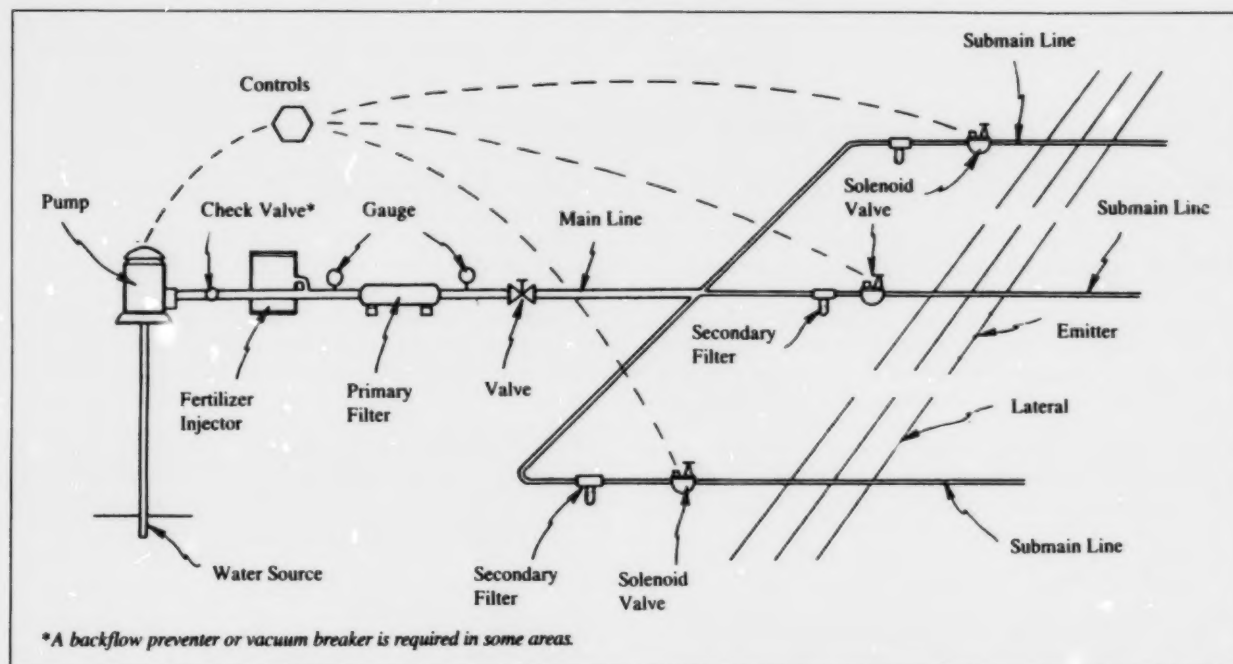


Figure 15. Trickle irrigation system components (used with permission from *Trickle Irrigation in The Eastern United States*, NRAES-4, Northeast Regional Agricultural Engineering Service).

A trickle system must be carefully planned. Parameters that affect the design of the system include the plant spacing, expected peak evapotranspiration rate, soil type, topography, leaching requirement and application efficiency. Water treatment requirements, filtration requirements and additional options should be discussed with a qualified irrigation specialist. Information is available from a qualified irrigation equipment dealer, public or private agricultural engineer and the OMAF Horticultural Crop Advisor.

Trickle irrigation is the most common and preferred system for water delivery (Figure 16). Advantages of trickle irrigation include: the need for a smaller water source; low pressure and even flow rates means less energy is required; high degree of water control is possible; once installed, labour and operating costs are generally less; the system can be automated; harvesting and watering can be done simultaneously; fertilizers can be injected through the system; leaves are not left wet; and it is suitable for hilly terrain. Some disadvantages include: clogging of emission orifices (a clean water source is essential); moisture distribution is limited; the system is susceptible to damage by rodents and field equipment; a high level of management is required; and it is more expensive initially.

OVERHEAD IRRIGATION With overhead irrigation, aluminum pipes are spaced out to deliver even patterns of water through rotating sprinklers. The sprinklers should be on high risers above the plants.



Figure 16. Trickle irrigation lines are laid within the raspberry rows at the base of the canes to ensure consistent watering of the plants.

An overhead system has the advantage of being portable so it can be used on other areas of the farm, spreading the capital costs over several commodity crops. However, the pipes become an obstruction for equipment and harvesting manoeuvres, and plants cannot be watered during harvest. Irrigating soaks the plants which increases the potential for cane and fruit diseases, especially during slow drying conditions.

WATERING The raspberry plant is watered on an intermittent basis according to need, but always before symptoms of wilt appear. The amount of water to be applied depends on the soil type, weather conditions, and plant stand. Different soil types have different water-holding capacities. A sandy, sandy loam and loam soil have 1.3, 3.8 and 5 cm of available soil moisture respectively per 30 cm of soil. Irrigation should begin when 50% of the available moisture has been lost. A tensiometer or other soil moisture measuring device can be used to estimate these levels. Alternatively, soil moisture losses (through evaporation and transpiration) and soil moisture additions (through rain and irrigation) can be monitored (i.e. water balance sheet method). Soil moisture levels can also be roughly estimated by feeling the soil.

Raspberries have an effective rooting zone of 60 cm. Therefore, on a sandy loam soil there is 7.6 cm of available water in the rooting zone. Since raspberries require 0.5 to 0.8 cm of water per day (during their peak use), 50% of the

moisture will be used within 5-8 days. Enough water should be added to restore the available moisture in the top 60 cm back to the 90-100% level. Overhead sprinklers are about 75% efficient, so 4 cm of applied water is needed to supply 3 cm of available moisture to the soil with an overhead system.

Irrigation must be used with care. Excessive watering late in the season can delay maturity, increasing the possibility of winter injury (but a dry fall can cause similar effects). Excessive irrigation is wasteful and results in soft berries that are much more perishable, limits soil aeration due to waterlogging which is conducive to root diseases, and overwatering leaches nutrients below the root zone.

In Ontario, there is a "Permit to Take Water Program" administered by the Ministry of the Environment. If more than 50,000 L/day is required or if irrigating is liable to cause interference with any public or private interest by decreasing the water levels, a permit must be obtained.

POLLINATION

Red raspberries are self-fruitful, but require insects for adequate pollination. Poor pollination results in crumbly berries, although many other factors can induce them. Bees are responsible for 90-95% of raspberry pollination (Figure 17). Raspberry flowers have a high nectar content and are naturally attractive to bees. Therefore large wild populations will forage raspberries. The natural bee population can be complemented by placing bee colonies in the field at bloom. Information on bee pollination and hive placement can be found in OMAF Publication 72, *Pollination: Crops and Bees*.

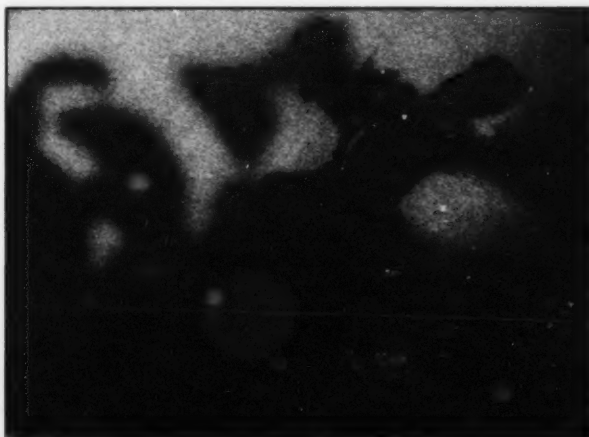


Figure 17. Raspberry flower receptive to pollination.

HARVESTING AND HANDLING

During peak production, red raspberries must be harvested frequently (e.g., every second day). Depending on the crop load, 15-20 pickers are needed per hectare. Pickers should be trained to pick the berries when they first turn completely red before darker hues develop so that the berries are firm. Ripe berries will come away easily and leave the core on the bush. Red berries which are missed will attract insects and become moldy or mushy before the next picking. For convenience, a light portable stand to hold the picking trays or a basket (containing boxes) tied around the waist will free both hands for harvesting. The berries are pulled gently with the thumb and forefinger and only a few berries should be held in the hand before they are carefully placed in the container. Berry damage caused by picking or poor handling is the main cause of berry deterioration before they are consumed.

The berries should not be handled more than necessary. Harvest directly into small containers that are to be marketed. Half pints are preferred, but pint boxes are also used in the fresh market trade. For processing, shallow trays without boxes can be used.

Once picked, the berries should be moved from the field as soon as possible and cooled rapidly. Rapid cooling is accomplished by forcing cool air through the containers (Figure 18). Raspberries should be cooled to 4°C and held near 0°C with a relative humidity of 85-90%. Delaying the cooling process or holding the berries at higher temperatures will decrease length of shelf-life significantly due to water loss, physiological deterioration and rot (gray mold). Berries sprayed for fruit rot during the season (see OMAF Publication 360, *Fruit Production Recommendations*) will store better than unsprayed berries.

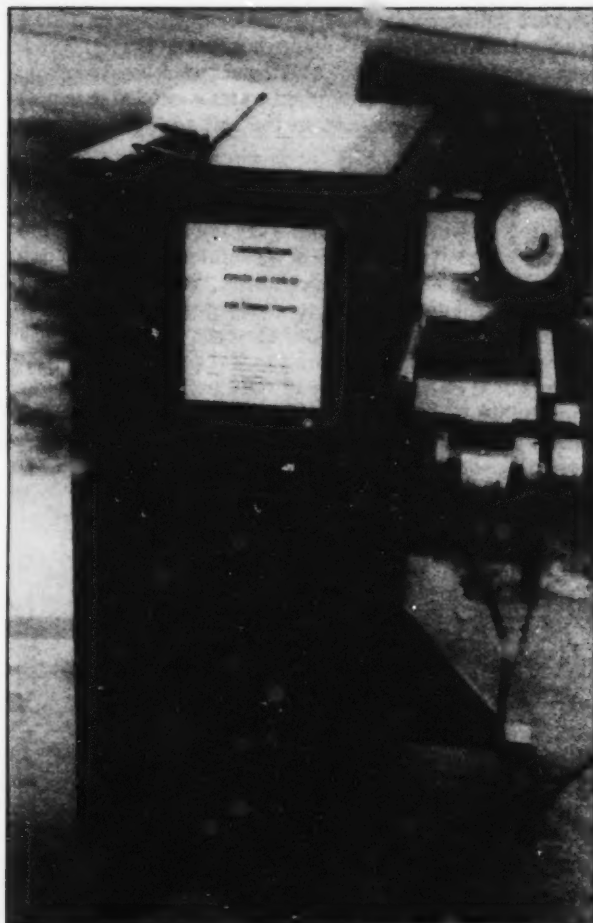
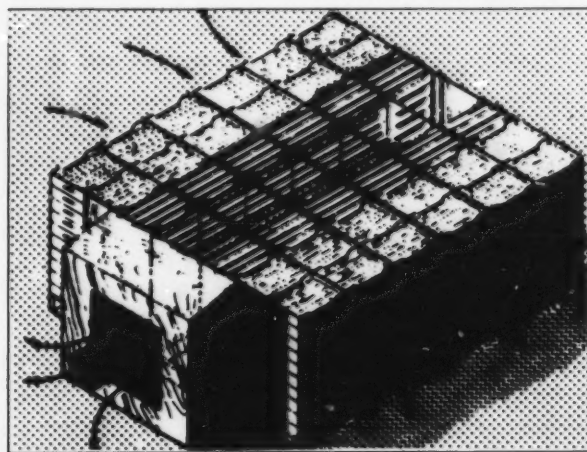
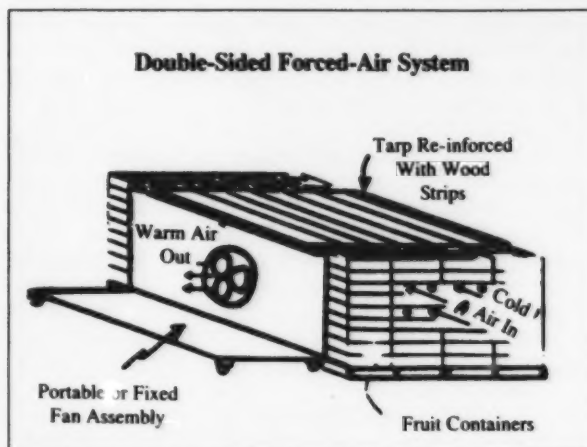


Figure 18. Schematic diagram of rapid cooling apparatus for raspberries. This unit is set within a cooler and draws air through the raspberry flats and removes the field heat as quickly as possible. Design by Hugh Fraser, OMAF, Vineland.



Courtesy: Engineering Service, Ministry of Agriculture, Fisheries & Food, Saint-Foy, Quebec.

Information on designing a forced-air rapid cooling system can be obtained from OMAF Horticultural Crop Advisors.

PICK-YOUR-OWN OPERATIONS

Pick-your-own (PYO) is a popular approach to harvesting raspberries. Location is very important when considering this approach to harvesting. Some markets near urban centers are saturated and other areas are too distant from a major source of customers. PYO is well suited for raspberries and is successful when carefully planned. Aspects to consider include advertising, rules, parking, organization,

containers, aesthetics of the farm (Figure 9), facilities, and possibly some form of recreation. Many different approaches have been used and helpful information is available. For sources of information see OMAF Factsheet, *Pick-Your-Own Harvesting*, Agdex 202/51, (a list of fruit and vegetable farmers markets), or contact a Horticultural Crop Advisor.

MECHANICAL HARVESTING

Machines are available for harvesting raspberries. They are expensive and large plantings are needed to justify the investment. Machine-harvested berries are used primarily for the processing market. Several types of harvesters are

available. Pruning and training practices must be adjusted accordingly. A budget and market plan must be carefully evaluated before investing in a harvester. Experience in Ontario with mechanical harvesters is limited.

YIELDS AND DURATION OF PLANTINGS

The average yield in Ontario is around 7,000 pints/ha. Potential yields are much higher than this. Careful attention to all production details is needed to obtain higher yields.

Raspberries can be profitably harvested for 12 years or more. However, many plantings decline to uneconomical

levels after 6 crops. Limitations include weed and disease problems. Virus diseases, particularly, lead to the decline of plantings. Use of certified plants, appropriate cultivars, recommended herbicides and good culture and pest management practices are essential for extending the profitability of the planting.

ECONOMICS OF PRODUCTION

Raspberries are a minor crop in Ontario with an estimated farm gate value of 3-4 million dollars. This represents 3% of the total farm gate value of all fruit crops. Being a minor crop, research on production practices and the economic feasibility of these practices has not been totally elucidated for optimum returns. Decisions on cultural practices and marketing strategies ultimately lie in the hands of the producer.

Long-term financial management is essential. The Economics and Policy Coordination Branch of OMAF publish estimated production costs and returns for fruit crops each year in *Fruit Crops: Estimated Production Costs*. A complete report is available through local OMAF offices, but a brief summary follows:

The 1989 estimates reveal that for the average producer in Ontario with yields of 6,672 pints/ha (2,700 pints/acre)¹ the gross return per hectare is \$8,340 for PYO operations and \$12,676 for fresh market operations. Typical variable costs (e.g., fertilizers, sprays, harvest containers, etc., ex-

cluding harvest labour) amounted to \$3,210/ha. Fixed costs (wages for the owner, depreciation on machinery and buildings, opportunity cost of 5% on the land, etc.) amount to \$3,218/ha. Subtracting the initial costs of establishment amortized over 5 years at a rate of 6.8% (\$2,834/year) results in a net return of \$1,423 and \$2,050/ha/year for PYO and fresh market businesses respectively.

Of course, some growers realize a net return much higher than this while others consistently show poor returns and eventually quit growing raspberries.

Profit may not be the only factor in deciding to proceed with a raspberry planting. Some operations find they achieve better customer loyalty (in PYO operations) by providing a diversity of crops. Diversity has other advantages. In 1987, many parts of Ontario suffered a drought particularly early in the season. The strawberry crop failed and for a number of Ontario producers, a successful raspberry crop played an instrumental role in producing cash flow and keeping the enterprise in business for another year.

¹ Assumed price of PYO Harvest of \$1.25/pint, Fresh Market Harvest \$1.90/pint.

DISEASES AND INSECT PESTS

Many diseases and insect pests are controlled with the use of air-blast or air-assist sprayers in commercial plantings (Figure 19).

For descriptions of diseases and insect pests and control measures, see OMAF Factsheet, *Insects and Diseases of Cane Fruits*, Agdex 230/605 and OMAF Publication 360, *Fruit Production Recommendations*.

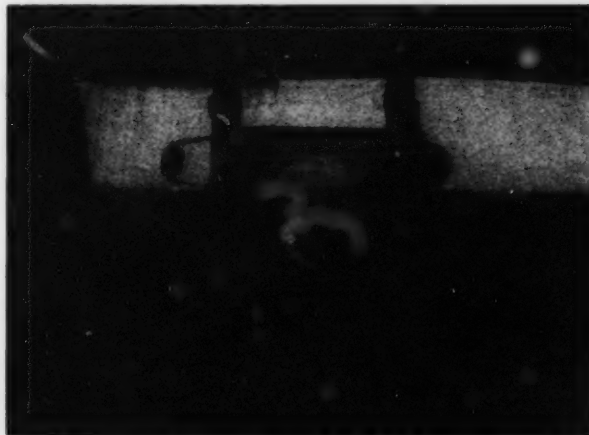


Figure 19. Air-assisted sprayer that can be used to ensure proper penetration of sprays into the center of the rows.